small, being only about one two-hundredth part of the whole appropriation for the Survey.

Another of the subordinate branches of the Coast Survey work is the determination of the earth's density. The pendulum, being an instrument which will swing faster or slower according as the force of gravity is stronger or weaker, can be employed to measure this force. All forms of pendulums will determine variations of gravity, but different shapes are given it, depending upon the particular object in view. That approaching nearest the ideal mathematical pendulum would be a heavy ball suspended by a fine string. This form was used by Borda, and a modification of it by Bessel consisted of swinging the ball with strings of different lengths. Kater employed a form known as the invariable one,—meaning by the term 'invariable' that none of the parts of the pendulum are interchangeable, and that the instrument remains identical for experiments made at different stations. Kater's pattern is generally preferred when the object is simply a determination of the differences of the force of gravity for different places. The reversible pendulum is one having two points of suspension, which are so placed that the times of oscillation are equal, or nearly so, whether the instrument is hung in the direct or reversed position. This form is used when the object is the determination of the actual force of gravity, or in other words, how far a body will actually fall towards the earth in a given time. As the distance between the two points of suspension is equal to the length of a simple pendulum which would oscillate in the same time, the determination of the force of gravity by this method becomes a comparatively simple matter as far as theory and principle are concerned. In the practical execution of the work there are difficulties that make it one of the highest precision, and at the same time one demanding the greatest care and attention to details.

In all pendulum experiments for the determination of gravity, whether relative or absolute, it is evident that the pendulum must swing under precisely the same circumstances, or the observations must be reduced to what they would have been had they been made under the same circumstances. The principal influences bearing on the duration of an oscillation, and those which vary most from one station to another, are the changes in the rate of the timekeeper, those resulting from differences in amplitude of the oscillations, and those dependent on the temperature of the pendulum and the pressure of the surrounding atmosphere.

The first two are readily disposed of, as one is independent of the pendulum and the other is a question of simple geometrical relations. The influence of the temperature may be determined either by swinging in great ranges of temperature and noting the changes in the period of oscillation for the two conditions, or by measuring the increase of length of the pendulum for a given increase of temperature and resorting to computation for the effect of this increase of length on the time of an oscillation. The pressure correction, or at least as much of it as is dependent on the buoyancy of the atmosphere, may likewise have two independent determinations. A part of this correction comes from the influence of the air that is set in motion, and depends on its viscosity. But the whole atmospheric effect may be eliminated from the length obtained for the seconds pendulum by using a reversible pendulum whose external form is symmetrical with reference to the centre of figure. The Coast and Geodetic Survey pendulums devised by Assistant C. S. Peirce are so made. Two different lengths are also used, one yard and several metre pendulums having been made at the Coast Survey Office in 1881. These instruments have been swung in many parts of the United States, from Boston in the east to San Francisco in the west, and from Albany in the north to Key West in the south. Besides these experiments, which were nearly all made near the sea-level, comparatively speaking, many determinations have been made at higher elevations in order to study the effect of distance from the earth's centre, and the attractions of mountains and table lands lying between the station and the sea-level.

In order to connect our series of pendulum observations with similar work done in Europe and other parts of the world, several of the principal pendulum stations in Europe were occupied with a Repsold reversible pendulum, and the same was swung also at some home stations. Also the Kater invariable pendulums, brought to this country by Captain Herschel, and which had been swung in different parts of the world, were swung at several of our stations as well as in New Zealand, Australia, the Malayan Peninsula, and Japan. The Coast and Geodetic Survey has thus secured an intimate connection with pendulum research the world over.

Outside our own country the Peirce pendulums have been sent to Lady Franklin Bay with the Greely expedition in 1882, to the South Pacific Ocean with the solar eclipse expedition of 1883, and to the Hawaiian Islands at the request of their government in 1887. In this last voyage both a yard and metre pendulum were swung at an elevation of ten thousand feet, and also at two stations at the sea-level. All this foreign work was done either by an officer of the Survey or by a trained observer following the most approved home methods.

The swaying of the stand on which the pendulum rests necessitates another correction to the time of oscillation in the case of absolute determinations. This source of error has been investigated mathematically by Professor Peirce. The English have used a small inverted pendulum attached to the stand for determining this correction.

The determination of the figure of the earth is one of the objects of pendulum observations. The force with which bodies attract each other depends on the quantity of matter in them and their distance apart. Places on the earth, therefore, which have an excess of matter, either from the material being of greater volume, or of greater density, will show a corresponding increase of the force of gravity; and places near the pole, from their being nearer the centre of the earth, would be expected to show a variation in the force of gravity in the same direction. Hence gravity determinations made at different points, starting from the equator and going towards the poles, will show the relative distances from the centre, and from this, with the aid of Clairaut's theorem, the shape of the earth. This would give a general figure for the sphere. Besides this, the pendulum will determine irregularities in this figure. In general, the result of pendulum observations thus far seems to indicate that gravity is in excess at island stations and coast-lines, and in defect on mountain tops; but this last may be partially due to the sea-level being raised in the neighborhood of continents by the attraction of the land, and the former is certainly influenced by the attraction of the surrounding sea-water. At any rate mountain observations point towards the conclusion that there may be either immense subterranean caverns beneath, or that the mass may be composed of lighter material than the earth's crust generally; and it may likewise be inferred that the stratum forming the bottom of the ocean is composed of comparatively heavy matter.

There are shown in this exhibit two reversible pendulums which have been used in the observations above described. One is a Peirce reversible metre pendulum swung in the heavy wooden frame devised for it by Professor Peirce, who has found it necessary to discard metallic stands. The other is the Repsold reversible metre pendulum referred to above. It is mounted now as it was when used, except that certain parts not necessary for showing the pendulum oscillations are omitted.

ENGLISH RAILROAD SPEEDS.

IN a recent letter from Manchester, England, to the *Railroad Gazette* of this city, Mr. W. H. Booth says that so important have been the changes made in the passenger traffic of all the great English companies, and also so numerous, that 'Bradshaw,' guide to all British lines, did not appear until the 3d of July. The alterations, of course, as usual, date from July 1, and call for special notice. 'Bradshaw' is studied with especial zeal just now by old established travellers, for the numerous changes have quite overthrown their knowledge. All the three companies which conduct a traffic between London and Scotland have added new expresses or increased the speed of existing trains, and the train service between the large towns has also been greatly improved and accelerated. For some time past American superintendents of motive power, and master mechanics, have been priding themselves upon running a good second to their English colleagues, and even ven-

turing to hint that they would soon pass them. Now, however, as usual with all changes in England, the progress there has taken a great step forward, and even the lines south of London, or more properly speaking, of the Thames Valley, are waking up, and the French also have ventured to reduce the time of the Calais and Paris express some fifteen minutes.

The fastest train between London and Edinburgh has hitherto been the Great Northern, from King's Cross, and it has performed the journey of 396 miles in nine hours. This same train now performs the distance in eight hours and a half, and of this time there are twenty minutes taken up for lunch at York, so that the run is seen to be very excellent indeed. On the other hand, the Northwestern, which has hitherto done the 401 miles between London and Glasgow in ten hours, has knocked off a whole hour, and runs the distance in nine hours, at a speed of forty-four and a half miles per hour, including stoppages, which consume forty-five minutes. Hence, while running, the speed is over forty-eight and a half miles per hour. Of the distance of 401 miles, 190 are over the hills of the Lake district and the Scottish Lowlands, but are covered at the same speed, about forty-seven miles per hour. The Northwestern line has to climb to an elevation of 870 feet over Shap Fell, and the Caledonian sixteen hundred feet at Beattock, with long grades of seventy and seventy-five feet to the mile in both cases. The Midland, again, which attains an elevation of fifteen hundred feet near the head of the Eden Valley, and has a large number of severe curves and gradients, runs 423 miles between London and Glasgow in nine hours and twenty minutes. This is really a better performance than that of the Northwestern, for one of its trains runs twenty-two miles further in only twenty minutes more time. Of the sixty minutes reduction in time by the Northwestern train from Euston station, it is remarkable that the whole of it is taken out of the running time, for the stops are as frequent and as long as before.

The 250 miles between Manchester and Glasgow are completed in five hours and fifty minutes, with six stoppages.

Between Manchester and London there are run daily no fewer than forty-two trains, which maintain a speed, including stoppages, of over forty miles per hour, and as many as twenty-seven similar trains between London and Liverpool. From London to Manchester is 203½ miles, and the shortest time is four and a quarter hours, by the Great Northern, with a climb of a thousand feet, in Longdendale near Penistone. This run includes a stop of five minutes at Grantham and of four minutes at Sheffield. The time of this train is three hours and twelve minutes to Sheffield, which is 162¼ miles from London. The speed is thus close upon fifty-one miles to Sheffield, or, deducting a stop of five minutes at Grantham, over fifty-two miles per hour, and this allows nothing for the slacking off at stops and the time lost in attaining full speed, this loss being always considerable with the large-wheeled engines used in England.

These fast English expresses are by no means light trains: the Scotch expresses especially are long, fully loaded trains, and the speeds attained with regularity and punctuality as well as economically as regards fuel, ought to receive attention on this side of the Atlantic, where it is the fashion to believe or pretend to believe that English locomotives are inferior machines, and universally provided with rigid wheel base, and unprovided with either bogies or other means of axle radiation.

The incorrectness of this assumption is shown by the following facts. The three routes to Scotland are worked by the somewhat different types of locomotives owned by four English and three Scotch railways. One company, the London and Northwestern, employ a single pair of wheels in radial guides under the front end of the engine. Another, the Great Northern, use a four-wheel truck with cylindrical centre pin and no lateral motion, and the five others employ the Adams four-wheel bogie, which has practically universal motion, the centre pin being a portion of a sphere, and the lateral motion being regulated by adjustable springs instead of with links as in American trucks. Thus none of the heavy express engines running these important trains have a rigid wheel base.

Of the seven types of locomotives used, two are compound, one is outside connected, and the other four are inside connected. One has a single pair of drivers, one has four drivers but no coupling rods, being on Webb's system, and the other five have four coupled drivers.

Considerable difference of practice exists with regards to the means of enabling the carriages to pass round curves. All the routes use, more or less, six-wheel carriages, with from eighteen to twenty-one feet wheel base, the boxes having some lateral motion in the pedestals or axle guards as they are called. The standard practice of the London & Northwestern is, however, an eight-wheel carriage, the end wheels having a radial motion controlled by springs. The Midland uses American pattern six-wheeled trucks under long passenger carriages, and four-wheeled bogie, with independent semi-elliptical springs above each journal box, dispensing with the heavy equalizer and in some cases with bolster springs. Two other lines use trucks under long carriages only, and the others adhere generally to the six-wheel arrangement as being lighter and simpler, though the motion round curves is not so smooth.

A compound engine of Webb's system, and made by Beyer, Peacock & Co., of Manchester, will soon be tried upon the Pennsylvania. As many of the fastest English trains are run regularly by engines of this type, it will be of interest to note their performance on American lines. Should the engine prove a failure, the cause certainly cannot be laid to the engine in the face of the scheduled speeds in 'Bradshaw,' which are not merely speeds on paper but represent what is actually performed. Possibly the inferior quality of American coal may be found unequal to supply steam in an English fire-box, which, for the work done, is generally smaller than in America. If this is not the case, there can be no reason for failure, apart from unskilful handling. With such an example of speeds before them is it not time that American trains made faster running than they do? England is a small country, and yet the English, who work much shorter hours than the Americans do, and must necessarily spend far less time in travelling between their large cities, are not satisfied unless they travel at the very highest possible speed. They certainly waste a half hour in stoppages during a run of eight and a half hours, mainly for dining. Actually therefore, they run four hundred miles in eight hours, and so would cover the nine hundred miles from New York to Chicago in eighteen hours, if they would dine on board the train. Travelling in England is very much simpler than in America. The use of sleeping cars is hardly necessary. Every important journey in the country is performed in less than nine hours, and the majority of the long journeys do not consume five hours. Hence sleepers and dining cars are a superfluity, with which few travellers in England care to be annoyed. In the United States they are indispensable, and perhaps their use has had something to do with the slowness of American trains.

SCIENTIFIC NEWS IN WASHINGTON.

The Topographic Maps of the United States Geological Survey; what They Are and What They Show. — The Proposed National Zoological Park; its Location and the Advantages of the Site. — How the Japanese Ferment, 'Koji,' is Made.

The United States Geological Survey's Topographic Maps.

"WHAT business has the United States Geological Survey to be spending the money appropriated for its work in making topographic maps on large scales?" is a pertinent question that is often asked, and more frequently of late since the Survey, in co-operation with some of the States, is rapidly pushing forward the work of mapping the area of those particular States to completion. "Why does not Major Powell, the Director of the Survey, send out his geologists to study, arrange, and represent on a geological map the rocks and minerals of the country, and let somebody else indicate on maps the hills and valleys, the forests and streams, the roads and towns?" This question contains an implied criticism of the management of the United States Geological Survey that is heard in Congress every session, and is repeated by men both in and out of government employ who think that the Survey is overstepping the limits fixed for it by law.

This question has been answered more than once, but it has been in testimony given before a commission or a committee of Congress, that never had a popular circulation, and which, if it had, is so voluminous and mixed up that very few persons would suc-